PB-218 406

# WATER SUPPLY AND WATER QUALITY CONTROL STUDY, GRANITE RESERVOIR, PECOS RIVER BASIN ABOVE SANTA ROSE, NEW MEXICO

Federal Water Pollution Control Administration
Dallas, Texas

August 1967

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

27

PB 218 406

# WATER SUPPLY AND WATER QUALITY CONTROL STUDY GRANITE RESERVOIR PECOS RIVER BASIN ABOVE SANTA ROSA, NEW MEXICO

**Study of Needs and Value of Storage for Municipal and Industrial Water Supply and Water Quality Control**

RECEIVED
LIBRARY
MAY 18 1969
FWPCA, OHIO BASIN REGION
4676 COLUMBIA PKWY., CINTI., O. 45226

NATIONAL TECHNICAL
INFORMATION SERVICE

**UNITED STATES DEPARTMENT OF THE INTERIOR**
**Federal Water Pollution Control Administration**
**South Central Region**
**Dallas, Texas**
**AUGUST 1967**

25

# WATER SUPPLY AND
# WATER QUALITY CONTROL STUDY
# GRANITE RESERVOIR
# PECOS RIVER BASIN ABOVE SANTA ROSA,
# NEW MEXICO


## Abstract

A survey has been made which discloses a need for municipal and industrial water supply in Las Vegas, New Mexico. There is no foreseeable need for storage for water quality control purposes in the project reservoir. These conclusions are based on results of economic and demographic studies.


Prepared for

DEPARTMENT OF THE ARMY

U.S. Army Engineer District

Albuquerque, New Mexico


UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
South Central Region
Dallas, Texas

AUGUST 1967

TABLE OF CONTENTS


| | Page |
|---|---|
| LIST OF TABLES | iii |
| LIST OF FIGURES | iii |
| I. INTRODUCTION | |
| Request and Authority | I-1 |
| Purpose and Scope | I-1 |
| Acknowledgments | I-1 |
| II. SUMMARY OF FINDINGS AND CONCLUSIONS | |
| Summary of Findings | II-1 |
| Conclusions | II-1 |
| III. PROJECT DESCRIPTION | III-1 |
| IV. STUDY AREA DESCRIPTION | IV-1 |
| V. WATER RESOURCES OF THE STUDY AREA | |
| General | V-1 |
| Quantity of Water Available | V-1 |
| Quality of Water Available | V-1 |
| VI. THE ECONOMY | |
| Present | VI-1 |
| The Future | VI-2 |
| VII. WATER REQUIREMENTS | |
| Past and Present Water Use | VII-1 |
| Future Requirements | VII-1 |
| Water Supply Plan | VII-1 |

TABLE OF CONTENTS (Continued)


| | | Page |
|---|---|---|
| VIII. | WATER QUALITY CONTROL | |
| | General. . . . . | VIII-1 |
| | Water Quality Objectives . . . . . | VIII-1 |
| | Municipal and Industrial Pollution . . . . . | VIII-1 |
| | Flow Regulation. . . . . | VIII-1 |
| IX. | BENEFITS | |
| | Water Supply . . . . . | IX-1 |
| | Water Quality Control. . . . . | IX-1 |
| X. | BIBLIOGRAPHY . . . . . | X-1 |

## LIST OF TABLES


| Number | Title | Page |
|---|---|---|
| V-1 | Runoff Values. . . . . | V-1 |
| V-2 | Monthly Distribution of Uncontrolled Runoff, Pecos River at Santa Rosa. . . . . | V-2 |
| V-3 | Chemical Analysis of Impounded Water for Las Vegas . . . . . | V-3 |
| V-4 | Characteristic Analysis of Water from Municipal Wells in the Pecos River Subbasin . . . . . | V-4 |
| VI-1 | Historic and Projected Population for the Study Area . . . . . | VI-2 |


## LIST OF FIGURES


| Number | Title | Following Page |
|---|---|---|
| III-1 | Location Map. . . . . | X-1 |
| VII-1 | Water Rights and Irrigation Land. . . . . | VIII-1 |

# I. INTRODUCTION

## Request and Authority

In a letter dated February 3, 1965, the U.S. Army Engineer District, Albuquerque, New Mexico, requested that the Public Health Service investigate and report on the need for and value of storage for municipal, industrial, and water quality control purposes in the Pecos River basin above Santa Rosa, New Mexico.

The water supply portion of this study was made in accordance with the Memorandum of Agreement, dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare relative to the Water Supply Act of 1958, as amended (43 U.S.C. 390b). The water quality control aspects are considered under authority of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.). Responsibility for these activities was transferred from the Department of Health, Education, and Welfare to the Department of the Interior by Reorganization Plan No. 2 of 1966, effective May 10, 1966.

## Purpose and Scope

The purpose of this study is as follows:

1. Determine present water use and estimate future water requirements.

2. Determine capabilities and suitabilities of existing and potential water resources to meet current and future needs.

3. Estimate the effect of present and future return flows on the quality of waters in the basin.

4. Determine the need for and value of storage in Federal reservoir projects for water supply and/or water quality control.

The area studies includes San Miguel and Guadalupe Counties in northeastern New Mexico.

## Acknowledgments

The cooperation of many persons and agencies is gratefully acknowledged. Special appreciation is expressed to the following:

U.S. Army Engineer District, Albuquerque, New Mexico
U.S. Fish and Wildlife Service, Albuquerque, New Mexico
New Mexico Department of Public Health, Santa Fe, New Mexico
State Engineer's Office, Santa Fe, New Mexico

I-2

Bureau of Mines and Mineral Resources, Socorro, New Mexico
Public Service Company, Las Vegas, New Mexico

# II. SUMMARY OF FINDINGS AND CONCLUSIONS

## Summary of Findings

1. The Corps of Engineers, Albuquerque, New Mexico, is making an investigation to determine the feasibility of constructing Granite Reservoir, a multipurpose structure, on the Gallinas River, a tributary to the Pecos River.

2. The study area consists of San Miguel and Guadalupe Counties in northeastern New Mexico.

3. The study area had a total 1960 population of 29,078. Las Vegas, with 13,818 persons, accounted for all of the urban population.

4. There are no heavy water-using industries in the study area; the water demand is therefore primarily municipal with small service industry use. In 1960, an estimated 13,500 persons were served by Las Vegas water facilities, using an average of 1.2 million gallons per day (mgd) for a per capita use of 87 gallons per day (gpcd). Las Vegas receives its water supply from the Gallinas River and four wells in the proximity of the city.

5. Following secondary treatment, the sewage from Las Vegas, which amounted to about 1.0 mgd in 1960, is discharged to the Gallinas River.

6. The quality of the headwaters of the Pecos River basin is good, although mineral concentrations increase progressively downstream. Ground water is generally satisfactory for domestic, irrigation, and stock use.

## Conclusions

1. The study area is expected to reach a total population of 34,000 in 2020 with a corresponding urban population of 25,000. In 2070, the total population is expected to reach 47,000 with 35,000 urban dwellers.

2. Projections to the year 2020 indicate a municipal water requirement for Las Vegas of 3.3 mgd with this increasing to 4.6 mgd by the year 2070.

3. Storage in proposed Granite Reservoir to satisfy this water requirement is presently needed.

4. The use of treated waste flow from Las Vegas for irrigation negates the need for storage for water quality control in the foreseeable future.

5. The value of benefits attributable to storage for municipal water supply, as determined by the cost of the most likely alternative to the project, amounts to $113,000 annually.

6. With no foreseeable need for storage for dilution flow, there is no benefit attributable to storage for this purpose.

# III. PROJECT DESCRIPTION

The Corps of Engineers is studying the feasibility of constructing Granite Reservoir on the Gallinas River about 7 miles above Las Vegas. The location of this reservoir is shown on figure III-1 following page X-1.

# IV. STUDY AREA DESCRIPTION

The study area is comprised of San Miguel and Guadalupe Counties in northeastern New Mexico. General features of the watershed are shown on figure III-1. The subbasin is approximately 90 miles long and 50 miles wide.

The Pecos River rises in the southern tip of Mora County, New Mexico, in the Sangre de Cristo Mountains at an elevation of about 13,000 feet. The river then flows in a southeasterly direction through deep precipitous canyons and gorges while dropping rapidly in elevation to about 4,500 feet at Santa Rosa. The principal tributaries are Cow Creek, Tecolote Creek, and the Gallinas River.

The climate of the study area is semiarid and temperatures are usually mild throughout the year. At Las Vegas,* the average annual temperature is 49° F., the average annual precipitation is 16 inches, and the average frost-free period amounts to about 150 days. 1/

In 1960, Las Vegas had a population of 13,818, which accounts for all the urban population in the study area. There are no large industries in the area and government activities, and related trades and services are the mainstay of the economy.

*The city of Las Vegas and the town of Las Vegas, two separate political subdivisions, are considered as one entity in this report.

# V. WATER RESOURCES OF THE STUDY AREA

## General

Control of the water resources of New Mexico was vested in the State at an early date to assure dependable supplies to those who developed them and to prevent waste.

"New Mexico law provides that the surface and underground waters of the State belong to the public and are subject to appropriation for beneficial use. Such use is the basis, the measure, and the limit to the right to use of water, and priority in time gives the better right. The underlying principle is known as the appropriative doctrine of water rights. Where it applies, the mere physical presence of water upon or within or adjacent to land does not confer upon the owner of the land ownership of the water or even a right to its use. Rather, water rights are established exclusively through use and rights established first must be served first." 2/ Water rights in New Mexico are administered by the State Engineer.

## Quantity of Water Available

### Surface Water

The Pecos River is a perennial stream except for a reach below Anton Chico where the flow percolates through the riverbed sands during periods of low flow, and reappears a few miles above Santa Rosa. Flow in the Gallinas River is perennial in the upper mountainous reach but becomes intermittent in the lower reach, with only a small amount reaching the Pecos River. 3/

The quantity of streamflow in the study streams was determined from period-of-record data at three U.S. Geological Survey discharge stations: Gallinas River near Montezuma, Pecos River near Pecos, and Pecos River at Santa Rosa. 4/ Table V-1 shows the average yearly discharges at different exceedence frequencies for each of the gaging stations.

Table V-1

Runoff Values

| Location of Station | Average Annual Runoff in cfs at Various Exceedence Frequencies (%) | | | | |
|---|---|---|---|---|---|
| | 98 | 95 | 90 | 80 | 50 |
| Gallinas River near Montezuma | 2.7 | 3.4 | 5.0 | 9.3 | 15.7 |
| Pecos River near Pecos | 30 | 35 | 43 | 61 | 97 |
| Pecos River at Santa Rosa | 31 | 43 | 55 | 71 | 107 |

The monthly distribution of uncontrolled runoff for the Pecos River at Santa Rosa is given in table V-2.

Table V-2

Monthly Distribution of Uncontrolled Runoff
Pecos River at Santa Rosa

| Month | % of Annual Flow | Month | % of Annual Flow |
|---|---|---|---|
| January | 2 | July | 12 |
| February | 2 | August | 22 |
| March | 2 | September | 7 |
| April | 5 | October | 4 |
| May | 23 | November | 2 |
| June | 17 | December | 2 |

Several existing and proposed impoundments are located in the study basin. Existing Storrie Lake is an offstream reservoir which impounds water diverted from the Gallinas River. The storage capacity of the reservoir is about 21,700 acre-feet, which is used for irrigation in the Storrie Project. Storage in Storrie Lake will be used to meet the water needs of the Las Vegas National Wildlife Refuge, presently under development in the vicinity of McAllister Lake.

Los Esteros Reservoir is an authorized Federal project located on the Pecos River at river mile 766.4. Storage in the reservoir has been allocated as follows: flood control, 245,400 acre-feet; irrigation, 200,000 acre-feet; and sediment reserve, 60,000 acre-feet.

A portion of the water supply for Las Vegas is from four reservoirs which impound water from the Gallinas River. The total storage capacity of these impoundments is about 640 acre-feet. In addition, three small lakes provide part of Santa Rosa's water supply.

## Ground Water

The upper study subbasin contains limestones of Pennsylvanian age which is the source of ground water. These limestones commonly contain much clay-like material that has a retarding effect on the solution of the limestone, the limestone itself has a low permeability. Small supplies of water generally are obtained from fractures in the limestone. Little information is available at present concerning depth to water or depth of wells required to develop these supplies. Farther south, in the vicinity of Santa Rosa, large supplies of water can be developed from the San Andres Limestone from wells drilled to a depth that is below the elevation of the Pecos River. Also, the Santa Rosa sandstone yields small to moderate supplies of water to wells in Guadalupe County. 2/

Las Vegas has four wells ranging from 810 to 880 feet in depth. The maximum yield of these wells varies from 125 to 440 gallons per minute (gpm), with a total of 950 gpm (1.4 mgd). This quantity could not be sustained indefinitely, however. These wells are employed when surface supplies are inadequate to meet the demand.

## Quality of Water Available

### Surface Water

The quality of the headwaters of the Pecos River basin is good. Dissolved solids concentrations increase progressively downstream, however, as agricultural runoff and surface and ground water, contaminated with salt by dissolution from geologic formations, reach the river. Springs below Colonias are estimated to contribute approximately 258,000 tons of dissolved solids annually to the Pecos River. 3/

Since quality data for streams in the study subbasin is not available, the station on the Pecos River at Puerto de Luna, 5/ some ten miles downstream from Santa Rosa, was used. Weighted average annual concentrations of several chemical constituents based on 12 years of daily record, are as follows: dissolved solids, 1,385 mg/l; sulfates, 818 mg/l; chlorides, 70 mg/l; and hardness (as $CaCO_3$), 967 mg/l. In addition, chemical analysis of a grab sample taken from the service reservoir of Las Vegas is given in table V-3.

Table V-3

Chemical Analysis of Impounded Water for Las Vegas

| Item | Concentration (mg/l) |
|---|---|
| Iron (Fe) | 0.20 |
| Calcium (Ca) | .8 |
| Magnesium (Mg) | 4.9 |
| Sodium (Na) | 1.2 |
| Sulfate ($SO_4$) | 11 |
| Chloride (Cl) | 1.0 |
| Fluoride (F) | 0.25 |
| Nitrate ($NO_3$) | 0 |
| Total Hardness (as $CaCO_3$) | 135 |
| Total Dissolved Solids | 182 |
| pH (in pH units) | 8.2 |
| Date sample collected | 6-11-62 |

Source: New Mexico Department of Public Health 6/

## Ground Water

The chemical quality of ground water in the basin is generally satisfactory for domestic, irrigation and stock use. Chemical analyses of water from wells that serve Las Vegas and Santa Rosa are shown in table V-4.

Table V-4

Characteristic Analysis of Water From Municipal Wells in the Pecos River Subbasin

| | Santa Rosa | Las Vegas |
|---|---|---|
| Iron (Fe) | 0.16 | 0.01 |
| Calcium (Ca) | 58 | 36 |
| Magnesium (Mg) | 12 | 10 |
| Sodium (Na) | 6.2 | 95 |
| Sulfate ($SO_4$) | 59 | 16 |
| Chloride (Cl) | 7.5 | 14 |
| Fluoride (F) | 0.30 | 0.5 |
| Nitrate ($HO_3$) | 1.2 | - |
| Total Hardness (as $CaCO_3$) | 195 | 131 |
| Total Residue | - | 458 |
| Filterable Residue | 250 | |
| pH (in pH units) | 8.2 | 7.8 |
| Date of Collection | 12-1-64 | 11-27-56 |

Source: New Mexico Department of Public Health 6/

# VI. THE ECONOMY

An economic study was made of the study area and the resulting projections of population and industrial growth serve as a basis for estimating future water use requirements and waste discharges.

## Present

### Economic Geography

The study area consists of San Miguel and Guadalupe Counties in the semiarid climate of northeastern New Mexico. The 1960 population of the study area was 29,078. Las Vegas is the principal center of population with 13,818 persons in 1960.

### Resources Within the Area

The leading resources of the study area are a healthful climate, recreational activities, and items of historic interest. Santa Fe, historical capitol of New Mexico and noted tourist attraction, is located 65 miles from Las Vegas. Several indian pueblos, the Santa Fe basin winter sport area, and a State park are in the proximity of Santa Fe.

The Pecos and Gallinas Rivers have their sources in the Santa Fe National Forest with its Pecos Wilderness Area. Also, Storrie Lake State Park is located in the study area. The winter sport area of Sipapu lies 50 miles northwest of Las Vegas.

Land is unsuitable for dryland farming because of insufficient rainfall. The amount of irrigated acreage is quite small and crop production is low. In 1959, a total of 10,000 acres was irrigated in the study area. 7/ Mining activity is relatively limited, with most of the mining output used for local construction projects.

### Manufacturing

Manufacturing is relatively insignificant in the study area, employing 291 persons or less than 4 percent of the 1960 labor force. 8/ No heavy water-using industries are located in the study area at the present time.

### Other Industries in the Area

Employment from government activities is significant in San Miguel County. Santa Rosa in Guadalupe County relies heavily on through traffic trade for year-round economic activity, receiving a large portion of trade from out-of-state travelers.

Service industries, which include public employment, are the most significant employers in the area, accounting for over 70 percent of the total labor force in the study area in 1960. 8/

## The Future

Since there is no heavy water-using industry in the area at the present, and no evidence to show the potential development of heavy water-using industry, projections of population are relied on as an indicator of future water use. Historic and projected populations for the study area to the year 2070 are shown in table VI-1.

Table VI-1

Historic and Projected Population for the Study Area

| | Historic | | | Projected | |
|---|---|---|---|---|---|
| | Study Area | Urban | | Study Area | Urban* |
| 1930 | 30,663 | 9,097 | 1980 | 29,000 | 20,000 |
| 1940 | 36,556 | 12,362 | 2000 | 31,000 | 25,000 |
| 1950 | 33,284 | 13,763 | 2020 | 34,000 | 30,000 |
| 1960 | 29,078 | 13,818 | 2070 | 47,000 | 45,000 |

* The city of Santa Rosa is not presently classified by the Bureau of the Census as urban (2,500 or more population); however, it is expected to increase in population and be placed in this category by 1980.

Source: Historic, Bureau of Census 9/

# VII. WATER REQUIREMENTS

## Past and Present Water Use

Las Vegas receives its water from four wells and the Gallinas River. Santa Rosa's water supply is taken from three lakes and two wells.

In 1960, Las Vegas used 1.2 mgd for a daily per capita demand of almost 90 gallons; water usage by Santa Rosa was 0.2 mgd, for a daily per capita demand of 80 gallons. These values include service industries, since, as discussed in Chapter VI, there are no heavy water-using industries in the community.

## Future Requirements

Future water requirements for Las Vegas are based on population projections presented in Chapter VI and a unit water use which increases to 130 gpcd by 2020. This rate of water use is intended to include both municipal and service industries, and reflects the economic character of Las Vegas with no large users of water anticipated in the future.

The water requirements of Las Vegas are expected to be 3.3 mgd in 2020, and 4.6 mgd in 2070.

Another important water use in the study basin is irrigation, which represents a considerable portion of the demand on the water resources of the area. The maximum water demand for this purpose in the subbasin is about 38,000 acre-feet per year or 34 mgd. These values were determined from information obtained from the New Mexico State Engineers' Office, and were based on existing commitments and a maximum water duty of 1.5 to 2.0 acre-feet per acre. Figure VII-1 shows the general allocation of water rights and the irrigated acreage in the area.

## Water Supply Plan

Since significant quantities of ground water are not present in the vicinity of Las Vegas, it is planned to use this source as a reserve supply to meet unexpected conditions. Also, surface water is preferred because it feeds into the system by gravity, thereby eliminating high pumping costs, and because it offers a constant, dependable source of water supply. Storage in proposed Granite Reservoir, therefore, is presently needed for water supply for Las Vegas. The requirement is expected to increase to 4.7 mgd in 2070.

# VIII. WATER QUALITY CONTROL

## General

Water quality control is defined as any measure employed to enhance the utility, value, and attractiveness of waters used for purposes which are affected by changes in water quality. The use of water by man in his many activities and the subsequent return of waste effluent even after secondary treatment, causes some degradation of water quality. As population and the associated water demand increases, the problem caused by waste water becomes more significant. If the quality of the stream receiving this treated waste is reduced below acceptable limits, additional water of better quality is necessary to correct this condition. This report is concerned with the possible use of releases from Granite Reservoir on water quality in the Gallinas River.

## Water Quality Objectives

Presently, use of water from the Gallinas River in the affected reach of the stream is for irrigation. There are no anticipated municipal and/or industrial water users. Consideration of storage for water quality control, therefore, is for irrigation and aesthetic purposes.

## Municipal and Industrial Pollution

At the present time, the average return flow of Las Vegas is about 1.4 mgd, which is discharged to the Gallinas River some 58 miles above its confluence with the Pecos River.

The return flow is expected to increase to about 2.1 mgd in 2020, and 3.0 mgd in 2070. The projected municipal and industrial return flow of Las Vegas was estimated to be 65 percent of the water use and have an untreated ultimate BOD of 350 mg/l. Future water quality control requirements are based on the assumption that sufficient treatment of waste flow will remove 90 percent of the BOD. Since water in this area of the country is scarce, it is reasonable to expect this degree of treatment to obtain maximum use from the resources available.

## Flow Regulation

Flow in the Gallinas River is perennial in the upper mountainous reach but becomes intermittent in the lower reach. Approximately 60 to 70 percent of the time, little or no flow is recorded at the Colonias gage near the mouth of the river.

All of the flow in the Gallinas River which receives the treated effluent from Las Vegas is applied to irrigation lands downstream,

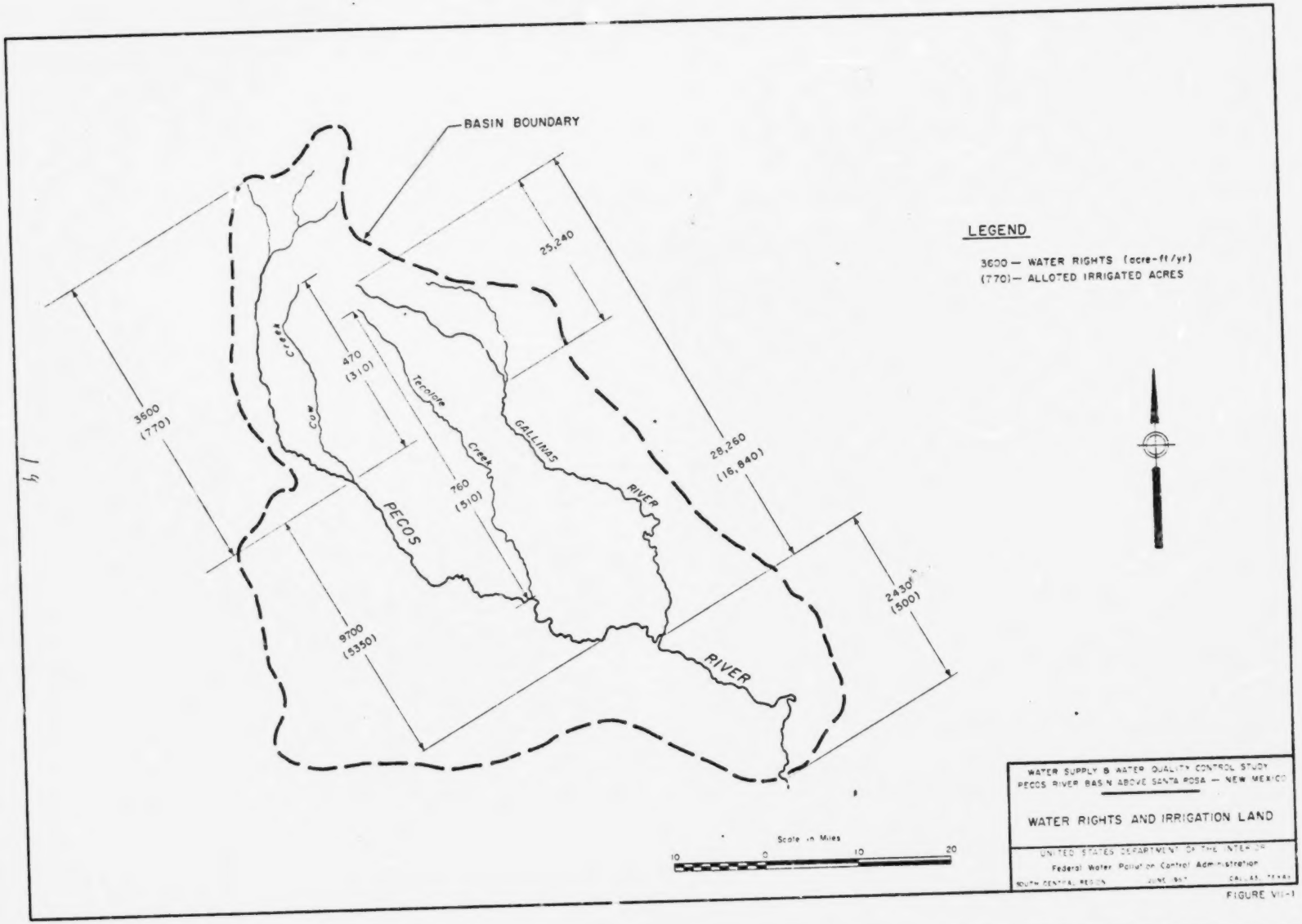
BASIN BOUNDARY
LEGEND
3600 — WATER RIGHTS (acre-ft/yr)
(770) — ALLOTED IRRIGATED ACRES
25,240
470
(310)
3600
(770)
Corral Creek
Tecolote Creek
760
(510)
GALLINAS RIVER
28,260
(16,840)
PECOS RIVER
9700
(5350)
2430
(500)
Scale in Miles
10 0 10 20
WATER SUPPLY & WATER QUALITY CONTROL STUDY
PECOS RIVER BASIN ABOVE SANTA ROSA — NEW MEXICO
WATER RIGHTS AND IRRIGATION LAND
UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
SOUTH CENTRAL REGION JUNE, 1967 DALLAS, TEXAS

FIGURE VII-1

except during periods of high or flood flows. Water rights for over 3,000 acre-feet annually (2.7 mgd) are allocated to irrigation in the reach of the river between Las Vegas and the mouth of the Gallinas River.

The quantity of water in the basin is limited, therefore maximum use of available water should be practiced. The use of sewage plant effluent for irrigation is an accepted practice throughout this section of the country with particular reference to nearby Santa Fe. Consideration should be given, therefore, to the sale of high quality, secondary-treated effluent to an irrigation district. This nutrient enriched effluent, if a reasonable degree of quality control is maintained, would offer a dependable and constant source of water to the irrigation project.

During the non-growing seasons, the effluent could be held in oxidation ponds and/or winter irrigation or pre-irrigation could be practiced. Normally, irrigation is practiced about 5 months of the year, the average frost-free period for this area being from mid-April to the beginning of October.

The Storrie Project, located adjacent and to the east of Las Vegas, contains 12,000 acres of irrigatable land. Essentially all of the water supply for the project is from flood waters, because of the relatively low priority of the water rights held.

The U.S. Bureau of Sport Fisheries and Wildlife is presently acquiring land in the Storrie Project for use as a Wildlife Refuge. The refuge would encompass approximately 4,000 acres of the 6,000 acres in the project which have sufficient water for irrigation. The remaining acreage could be irrigated with effluent from Las Vegas. Storage in Granite Reservoir for water quality control, therefore, is not needed in the foreseeable future.

# IX. BENEFITS

## Water Supply

The benefits of developing Granite Reservoir result from the provision of a dependable water supply. In addition, the existence of this reservoir would offer recreation such as swimming, fishing, boating, camping, and water skiing for those living in and near the study area. The sale of goods and services associated with these facilities would become a significant segment of the economy of the area. Also, property values in the vicinity of the impoundment would be improved. Finally, municipal and industrial water users would be provided a supply of more uniform physical and chemical quality, with proper operation of the reservoir.

Senate Document No. 97 (87th Congress, 2nd Session) makes the following statement concerning evaluation of benefits of municipal and industrial water supply storage in Federal reservoirs:

> "The amount water users should be willing to pay for such improvements in lieu of foregoing them affords an appropriate measure of this value. In practice, however, the measure of the benefit will be approximated by the cost of achieving the same results by the most likely alternative means that would be utilized in the absence of the project."

After consideration of ground water development it is concluded that the most reasonable alternative to the project is a single-purpose reservoir at the proposed project site. The cost of the alternate reservoir having an annual yield of 4.6 mgd is estimated to be $3,000,000, with an annual operation and maintenance cost of $15,000. It should be noted that Las Vegas has pueblo rights which grant prior rights to all water in the Gallinas River that Las Vegas needs, without purchase of downstream rights.

Based on a 100-year amortization period at an interest rate of 3 1/8 percent, the total annual cost of the single-purpose reservoir amounts to $113,000 or seven cents per thousand gallons.

The value of benefits attributable to storage in Granite Reservoir for municipal water supply, therefore, amounts to 113,000.

## Water Quality Control

Since there will be no foreseeable need for storage to control water quality, as discussed in Chapter VIII, there will be no benefits attributable to this purpose.

# X. BIBLIOGRAPHY

1. New Mexico State Engineer, Consumptive Use and Water Requirements in New Mexico, Blaney, Harry F., and Hanson, Eldon G., Santa Fe, New Mexico, 1965.

2. New Mexico State Engineer, Characteristics of the Water Supply in New Mexico, Santa Fe, 1965.

3. Bureau of Reclamation, Reconnaissance Report of Pecos River Basin, New Mexico - Texas, Amarillo, Texas, June 1960.

4. Geological Survey, Compilation of Records of Surface Waters of the United States, Part 8, Western Gulf of Mexico Basins.

5. Geological Survey, Quality of Surface Waters of the United States, Parts 7 and 8, Lower Mississippi River Basin and Western Gulf of Mexico, Washington, Government Printing Office.

6. Data from New Mexico Department of Public Health, Santa Fe, New Mexico.

7. Bureau of the Census, Census of Agriculture, 1960, Washington, Government Printing Office.

8. Bureau of the Census, Census of Population, "Characteristics of the Population," Washington, Government Printing Office.

9. Bureau of the Census, Census of Population, 1930, 1940, 1950, 1960, "Number of Inhabitants," Washington, Government Printing Office.

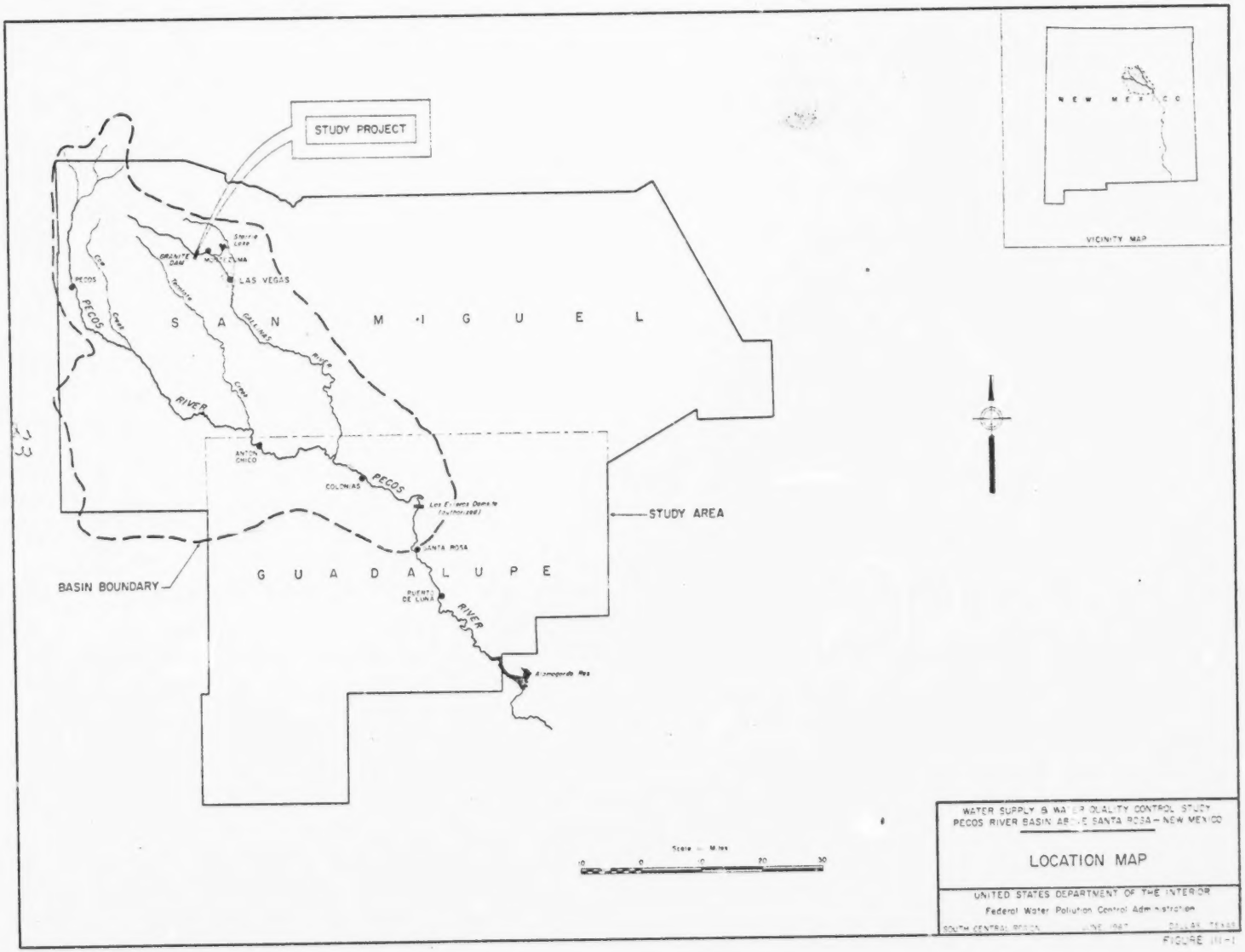
STUDY PROJECT
VICINITY MAP
NEW MEXICO
LAS VEGAS
GRANITE DAM
MONTEZUMA
PECOS
PECOS RIVER
GALLINAS RIVER
SAN MIGUEL
ANTON CHICO
COLONIAS
PECOS
Los Esteros Dam & Reservoir (Authorized)
SANTA ROSA
STUDY AREA
BASIN BOUNDARY
GUADALUPE
PUERTO DE LUNA
PECOS RIVER
Scale — Miles
10 0 10 20 30
WATER SUPPLY & WATER QUALITY CONTROL STUDY
PECOS RIVER BASIN ABOVE SANTA ROSA — NEW MEXICO
LOCATION MAP
UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
SOUTH CENTRAL REGION
DALLAS, TEXAS

FIGURE IM-1